FINAL PROGRESS REPORT FOR NAS5-98191:

A THREE-DIMENSIONAL ANALYSIS OF THE GALACTIC GAMMA-RAY EMISSION

RESULTING FROM COSMIC-RAY INTERACTIONS WITH THE

INTERSTELLAR GAS AND RADIATION FIELDS

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TASK LEADER: Thomas J. Sodroski
ATR: Eli Dwek

Description of Activities:

The contractor will provide support for the analysis of data under ADP (NRA 96-ADP-09; Proposal No . 167-96adp). The primary task objective is to contruct a 3-D model for the distribution of high-energy (20 MeV - 30 GeV) gamma-ray emission in the Galactic disk. Under this task the contractor will utilize data from the EGRET instrument on the Compton Gamma-Ray Observatory, H I and CO surveys, radio-continuum surveys at 408 MHz, 1420 MHz, 5 GHz, and 19 GHz, the COBE Diffuse Infrared Background Experiment (DIRBE) all-sky maps from 1 to 240 μm, and ground-based B, V, J, H, and K photometry. The respective contributions to the gamma-ray emission from cosmic ray/matter interactions, inverse Compton scattering, and extragalactic emission will be determined.

This task is supported by T. J. Sodroski (EITI).

Significant Accomplishments:

During this second year of our 2-year program we have successfully derived the respective contributions to the high-latitude ($|b| > 20°$) gamma-ray emission from cosmic-ray/matter interactions, inverse Compton scattering (i.e., including the Galactic gamma-ray halo component), and the extragalactic gamma-ray background component. A collaboration with the EGRET team at Goddard was established for continuation of project.

We were provided with source-subtracted EGRET data at high Galactic latitudes, derived using the source-removal algorithm developed by the EGRET team. A map of H-atom column density covering the total sky was obtained from the Leiden/Dwingeloo survey of H I over the northern sky ($\delta > -30°$) by Hartmann & Burton (1993, 1997), and the Cleary, Heiles, and Haslam (1979) H I survey of the southern sky ($\delta < -30°$). Maps of the inverse Compton emission in each EGRET energy interval were generated using the 3-D map of the Galactic interstellar radiation field field (ISRF) that was derived by our group from our analysis of COBE/DIRBE data and ground-based B, V, J, H, and K photometry of the Milky Way (See Final Progress Report For S-92504-Z). The local cosmic-ray electron intensity distribution of Fichtel et al. (1991), modified by Bertsch et al. (1993), was adopted. It was further assumed that the radial gradient of the CR electron intensity is equal to the gamma-ray emissivity gradient derived by Strong et al. (1988; Case 3, where shape of radial distribution is independent of gamma-ray energy), which is consistent with the results of Strong & Mattox (1996) using EGRET data. We set up an idl algorithm for generating maps of the source-subtracted gamma-ray emission, H I emission, and Inverse Compton model emission at comparable resolution.

We implemented a modelling algorithm to perform the high latitude decomposition with Poisson statistics. The algorithm was fitted to the point source-subtracted EGRET data for all 10 bands simultaneously (10480 lines of sight) in order to obtain the value of the absolute scaling factor for the local cosmic-ray electron intensity distribution, and for each EGRET energy interval the value of the gamma-ray emissivity due to due to nuclear interactions and bremsstrahlung collisions, the scale height of the cosmic-ray electrons responsible for the inverse Compton emission, and the extragalactic background intensity (total of 31 parameters). Our results are presented in Figures 1 – 3.

The determination of the contribution of inverse Compton scattering to the Galactic gamma-ray emission at low latitudes is currently being done in collaboration with the EGRET team at Goddard. We have reformatted our Galactic interstellar radiation field (ISRF) determination onto an interpolated grid suitable for their Galactic plane models (Bertsch et al. 1993; Hunter et al. 1997), and have been in close communication with their group to verify that our model is incorporated correctly.

Three papers (Sodroski et al. 2000; Odegard et al. 2000; Hunter et al. 2000) discussing the details of the analysis and results of our two year program are currently in progress. Sodroski et al. (2000) describe the analysis and results of the decomposition of the high-latitude EGRET data. Odegard et al. (2000) discuss the derivation of the local ISRF using DIRBE data. The results of the decomposition of the low-latitude EGRET data will be presented by Hunter et al. (2000).

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Cleary, M. N., Heiles, C., & Haslam, C. G. T. 1979, A&AS, 36, 95

Fichtel, C. E., Özel, M. E., Stone, R. G., & Sreekumar, P. 1991, ApJ, 374, 134

Hartmann, D., & Burton, W. B. 1993, in AIP Conf. Proc. 278, Back to the Galaxy, ed. F. Verter
    & S. S. Holt (New York: AIP), 279

Hartmann, D., & Burton, W. B. 1997, Atlas of Galactic Neutral Hydrogen (Cambridge:
    Cambridge University Press)

Hunter, S. D., et al. 1997, ApJ, 481, 205

Hunter, S. D., et al. 2000, in progress

Odegard, N. P., et al. 2000, in progress

Sodroski, T. J., et al. 2000, in progress

Strong, A. W., et al. 1988, A&A, 207, 1

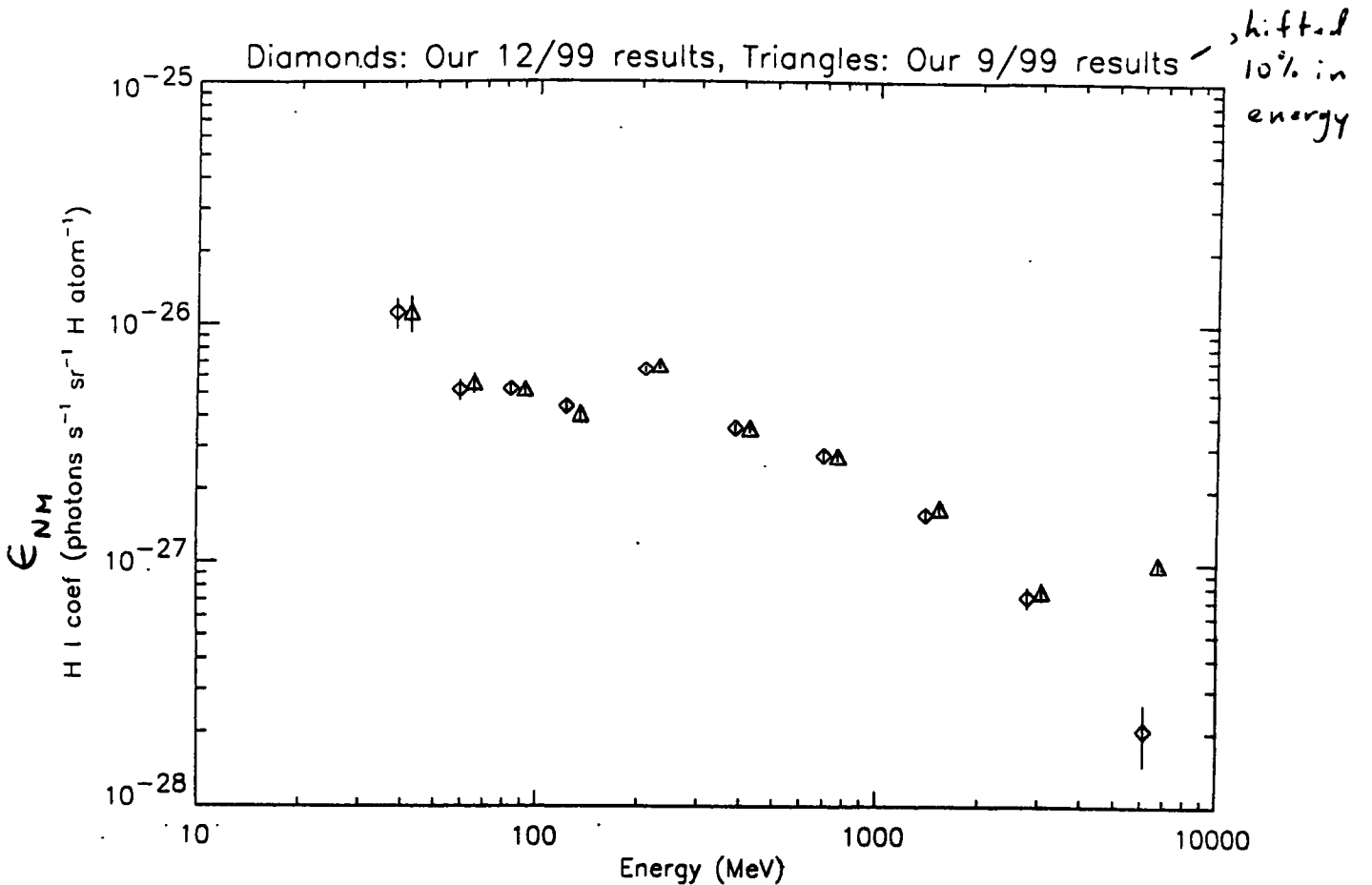Strong, A. W., & Mattox, J. R. 1996, A&A, 308, L21

Fig. 1.— Emissivity spectrum due to nuclear interactions and bremsstrahlung collisions.

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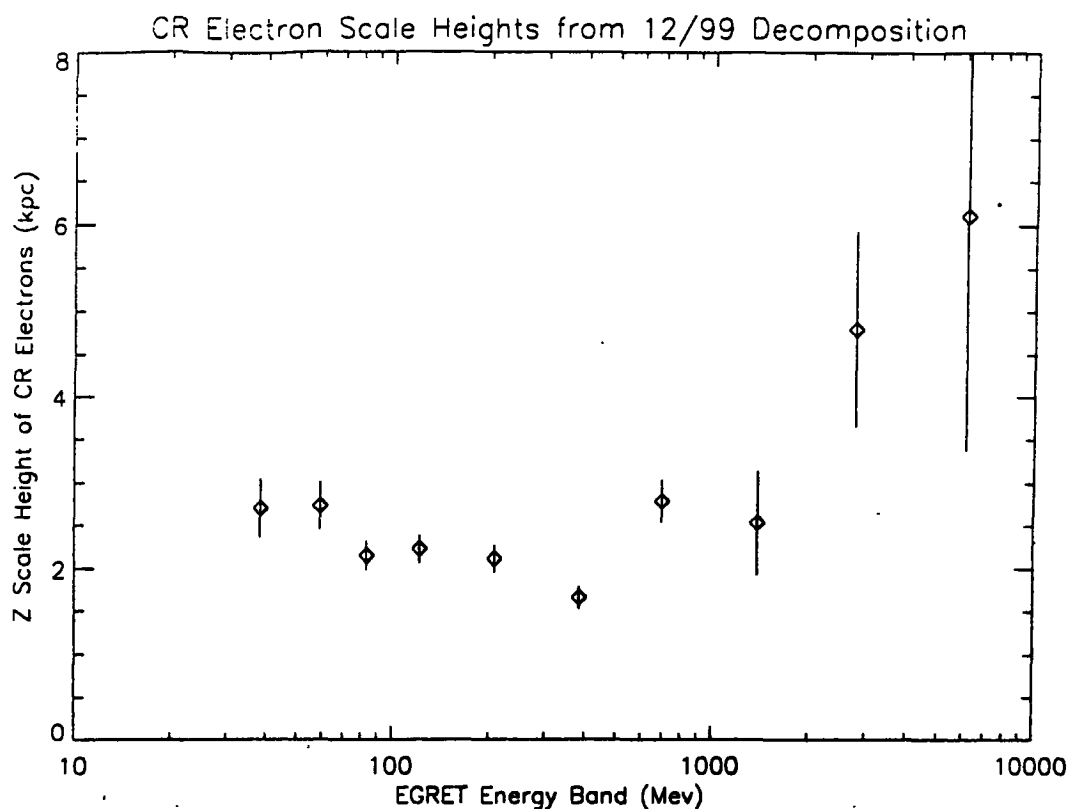## CR Electron Scale Heights from 12/99 Decomposition

Fig. 2. — The distribution of the scale height of the cosmic-ray electrons responsible for the inverse Compton emission in each EGRET energy interval.
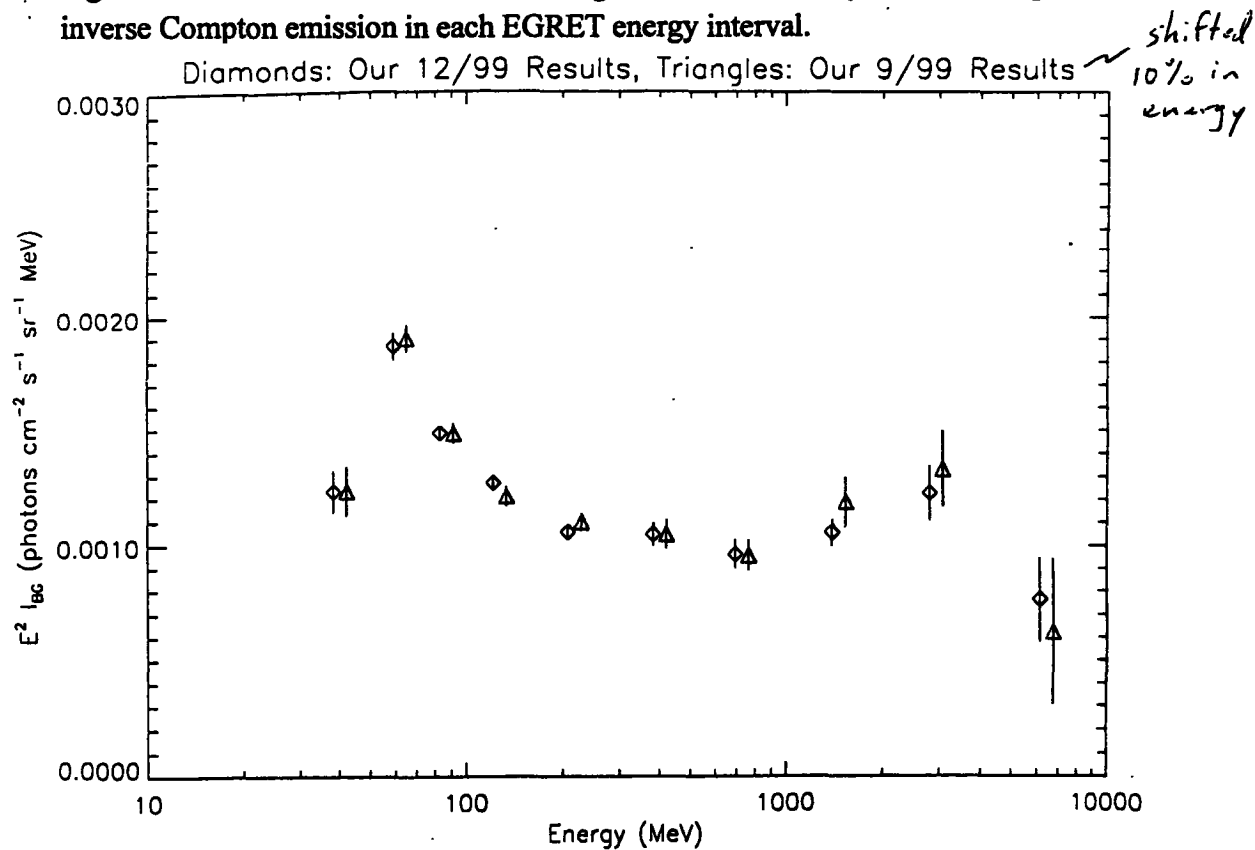

Diamonds: Our 12/99 Results, Triangles: Our 9/99 Results ← *shifted 10% in energy*

Fig. 3. — The extragalactic diffuse emission spectrum.

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Dr. Thomas Sodroski

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Space Applications Corporation
9315 Largo Drive West, Suite 250
Largo, MD 20774

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